

We claim:

1. An electric storage battery including:  
a case comprising a peripheral wall defining an interior volume; and  
5 an electrode assembly mounted in said interior volume, said electrode assembly including:  
an electrically conductive elongate pin; and  
first and second opposite polarity electrode strips wound together  
to form a spiral roll, each electrode strip having inner and outer ends,  
10 wherein said first electrode strip is electrically coupled to said pin at said inner end; and  
a hollow elongate mandrel closely fitted around said pin for mechanically reinforcing said pin.
- 15 2. The battery of claim 1 wherein said pin extends exteriorly of said case peripheral wall to function as a first battery terminal.
3. The battery of claim 1 wherein said mandrel is electrically coupled to said pin.
- 20 4. The battery of claim 1 wherein said first electrode strip inner end is directly connected to said pin by at least one weld.
5. The battery of claim 1 wherein said pin consists of a PtIr alloy.
- 25 6. The battery of claim 1 further comprising a first end cap mounted on said pin, said first end cap including an electrical insulator; and wherein said pin extends through and is hermetically sealed to said end cap electrical insulator.
- 30 7. The battery of claim 1 wherein said mandrel defines an elongate slot; and wherein  
said first electrode strip extends through said mandrel slot.

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8. The battery of claim A1 wherein said mandrel is welded to said pin.

9. The battery of claim A1 wherein said mandrel comprises titanium or an alloy thereof.

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10. An electric storage battery made by the steps of:  
providing an electrically conductive elongate pin having inner and outer ends;

providing a first polarity electrode strip;  
10 providing a second polarity electrode strip;  
electrically connecting a first end of the first polarity electrode strip to the pin proximate to the pin inner end;  
mounting a reinforcing mandrel on the pin; and  
winding together the first polarity electrode strip and the second polarity  
15 electrode strip to form a spiral roll having at least a portion of the pin within the spiral roll.

11. The battery of claim 10 wherein said steps further include the step of mounting the spiral roll in a case with the pin outer end extending exteriorly of  
20 the case to form a first battery terminal.

13. The battery of claim 10 wherein said steps further include the step of electrically coupling the reinforcing mandrel to the pin.

25 14. The battery of claim 10 wherein said step of winding together the first polarity electrode strip and the second polarity electrode strip comprises rotating the pin.

15. The battery of claim 10 wherein said step of providing an electrically  
30 conductive elongate pin includes a step of:

forming an end cap including an insulating member on the pin hermetically sealed thereto and positioned proximate to but spaced from the pin outer end.

16. The battery of claim 3 wherein said steps further include a step of mounting a conductive member around the insulating member; and electrically connecting the conductive member to the case.
- 5 17. The battery of claim 1 wherein said steps further include a step of welding the reinforcing mandrel to the pin.
18. The battery of claim 1 wherein the mandrel comprises a tube having a slot therein and wherein said winding step further includes the steps of:
- 10 inserting a drive key into the slot; and  
orbiting the drive key to rotate the mandrel and pin.
19. The battery of claim 1 wherein the mounted mandrel comprises a channel and wherein said steps further include a step of injecting electrolyte through the
- 15 channel.
20. A method of constructing an electric storage battery including:  
providing an electrically conductive elongate pin having inner and outer ends;
- 20 providing a first polarity electrode strip;  
providing a second polarity electrode strip;  
electrically connecting a first end of said first polarity electrode strip to said pin proximate to said pin inner end;  
mounting a reinforcing mandrel on the pin;
- 25 winding together said first polarity electrode strip and said second polarity electrode strip to form a spiral roll having at least a portion of the pin within the spiral roll.
21. The method of claim 20 and further including the step of:
- 30 mounting said spiral roll in a case with said pin outer end extending exteriorly of said case to form a first battery terminal.
22. The method of claim 20 and further including the step of:  
electrically coupling the reinforcing mandrel to the pin.

23. The method of claim 20 wherein said step of winding together the first polarity electrode strip and the second polarity electrode strip comprises rotating the pin.
- 5 24. The method of claim 20 wherein said step of providing said electrically conductive elongate pin includes a step of:  
forming an end cap including an insulating member on said pin hermetically sealed thereto and positioned proximate to but spaced from said pin outer end.
- 10 25. The method of claim 24 including the further step of mounting a conductive member around said insulating member; and  
electrically connecting said conductive member to said case.
- 15 26. The method of claim 20 including a further step of welding the reinforcing mandrel to the pin.
27. The method of claim 20 said step of mounting a reinforcing mandrel comprises mounting a mandrel comprising a tube having a slot therein; and  
20 wherein said winding step further includes the steps of:  
inserting a drive key into the slot; and  
orbiting the drive key to rotate the mandrel and pin.
28. The method of claim 20 wherein the said step of mounting a reinforcing  
25 mandrel comprises providing a channel and wherein said steps further include a step of injecting electrolyte through the channel.
29. An electrode assembly including:  
an electrically conductive, elongate pin;  
30 an elongate reinforcing mandrel mounted on at least a portion of said pin;  
and  
a spiral roll comprising first and second opposite polarity electrode strips and at least one separator strip separating said electrode strips mounted on said pin, wherein one of said electrode strips is electrically coupled to  
35 said pin.

30. The electrode assembly of claim 29 wherein said mandrel is C-shaped and defines a longitudinal slot; and wherein

an inner end of said first electrode strip extends through said mandrel slot and is electrically connected to said pin.

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31. The electrode assembly of claim 29 wherein said pin comprises a portion extending beyond said spiral roll to form a battery terminal.

32. The electrode assembly of claim 29 wherein said mandrel is crimped onto  
10 said pin.

33. The electrode assembly of claim 29 wherein the mounted mandrel has a channel through which electrolyte can be injected.

15 34. An electrode assembly made by the steps of:  
providing an electrically conductive, elongate pin;  
providing a first polarity electrode strip;  
providing a second polarity electrode strip;  
electrically connecting a first end of the first polarity electrode strip to the  
20 pin;  
mounting a reinforcing mandrel on the pin; and  
winding together the first polarity electrode strip and the second polarity  
electrode strip to form a spiral roll having at least a portion of the pin and the  
mandrel interior to the spiral roll.

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35. The assembly of claim 34 wherein said steps further include a step of crimping the reinforcing mandrel to the pin.

36. The assembly of claim 34 wherein said steps further include a step of  
30 welding the reinforcing mandrel to the pin.

37. The assembly of claim 34 wherein said step of winding together the first polarity electrode strip and the second polarity electrode strip comprises rotating the pin and the mandrel.

38. The assembly of claim 34 wherein said step of winding together the first polarity electrode strip and the second polarity electrode strip to form a spiral roll comprises leaving a portion of the pin extending beyond the spiral roll to form a  
5 battery terminal.

39. A method of constructing an electric storage battery including:  
 providing an electrically conductive, elongate pin;  
 providing a first polarity electrode strip;  
 10 providing a second polarity electrode strip;  
 electrically connecting a first end of said first polarity electrode strip to said pin;  
 mounting a reinforcing mandrel on said pin; and  
 winding together the first polarity electrode strip and the second polarity  
 15 electrode strip to form a spiral roll.

40. The method of claim 39 including the further step of crimping the reinforcing mandrel to the pin.

20 41. The method of claim 39 including the further step of welding the reinforcing mandrel to the pin.

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 42. The method of claim 39 wherein said step of winding together the first polarity electrode strip and the second polarity electrode strip comprises rotating  
 25 the pin and the mandrel.

<sup>43</sup>  
~~42.~~ The method of claim 39 wherein said step of winding together the first polarity electrode strip and the second polarity electrode strip to form a spiral roll comprises leaving a portion of the pin extending beyond the spiral roll to form a  
 30 battery terminal.

<sup>44</sup>  
~~43.~~ An electric storage battery comprising:  
 an electrically conductive case sealed by first and second end caps;  
 an electrically conductive terminal pin extending through said first end cap

and electrically insulated from said case;

an electrode assembly disposed within said case and comprising first and second opposite polarity electrodes separated by separators wherein said first electrode is electrically coupled to said pin;

5 a flexible conductive tab electrically coupled to said second electrode proximate a first location at the seal formed between said second end cap and said case;

wherein said second end cap has a center and wherein said second end cap has a width from said first location to a second location at the seal formed  
10 between said second end cap and said case measured along a line through said center; and

said tab electrically connected to said second end cap at a third location between said second location and said center of said second end cap.

15 <sup>45</sup>/<sub>44</sub>. The battery of claim 43 wherein said case has no separate fill hole.

<sup>46</sup>/<sub>45</sub>. The battery of claim 43 wherein said second end cap is welded to said tab flat against an inner face of said second end cap.

20 <sup>47</sup>/<sub>46</sub>. The battery of claim 43 wherein said second end cap is circular and wherein said width is a diameter.

<sup>48</sup>/<sub>47</sub>. An electric storage battery made by the steps of:  
providing a case comprising a peripheral wall of electrically conductive  
25 material defining an interior volume and having first and second wall openings communicating with the interior volume;

providing an electrically conductive terminal pin extending through a first end cap and electrically insulated from the case

providing an electrode assembly comprising first and second opposite  
30 polarity electrodes

electrically connecting the first electrode to the pin;

forming a flexible conductive tab extending beyond a second edge of the electrode assembly and electrically connected to the second electrode ;

mounting the electrode assembly in the interior volume with the pin

- extending out through the first wall opening and the tab extending out through the second wall opening;
- mounting the first end cap to seal the first wall opening;
- providing a second end cap of electrically conductive material; and
- 5 fastening the second end cap to the tab in a manner to provide an electrical connection therebetween.

47. The electric storage battery of claim 47 wherein said steps further include a further step of depositing electrolyte into the case through the second wall opening following said step of fastening the second end cap to the tab.

48. The electric storage battery of claim 47 wherein said step of fastening the second end cap to the tab includes welding the tab flat against an inner face of the second end cap.

15 49. The electric storage battery of claim 49 including the further step of mounting the end cap in the second wall opening to seal the second wall opening.

20 50. A method of constructing an electric storage battery including:  
 providing a case comprising a peripheral wall of electrically conductive material defining an interior volume and having first and second wall openings communicating with the interior volume;  
 providing an electrically conductive terminal pin extending through a first  
 25 end cap and electrically insulated from the case  
 providing an electrode assembly comprising first and second opposite polarity electrodes wherein the first electrode is electrically connected to the pin;  
 forming a flexible conductive tab extending beyond a second edge of the electrode assembly and electrically connected to the second electrode ;  
 30 mounting the electrode assembly in the interior volume with the pin extending out through the first wall opening and the tab extending out through the second wall opening;  
 mounting the first end cap to seal the first wall opening;  
 providing a second end cap of electrically conductive material; and

fastening the second end cap to the tab in a manner to provide a mechanical and electrical connection therebetween.

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52. The method of claim 51 including a further step of depositing electrolyte  
5 into the case through the second wall opening after said step of fastening the second end cap to the tab.

54  
53. The method of claim 51 wherein said step of fastening the second end cap to the tab includes welding the tab flat against an inner face of the second  
10 end cap.

55  
54. The method of claim 53 including the further step of mounting the end cap in the second wall opening to seal the second wall opening.

15 56  
55. An electric storage battery comprising:  
an electrically conductive case hermetically sealed by first and second end caps, wherein said case has no separate fill holes and wherein said first and second end caps have no separate fill holes;  
an electrically conductive terminal pin extending through said first end cap  
20 and electrically insulated from said case;  
an electrode assembly disposed within said case and comprising first and second opposite polarity electrodes separated by separators wherein said first electrode is electrically coupled to said pin; and  
a flexible conductive tab electrically coupled to said second electrode and  
25 to said second end cap.

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56. An electric storage battery made by the steps of:  
providing a case comprising a peripheral wall of electrically conductive material defining an interior volume and having first and second wall openings  
30 communicating with the interior volume;  
providing an electrically conductive terminal pin extending through the first end cap and electrically insulated from the case;  
providing an electrode assembly comprising first and second opposite polarity electrodes

electrically coupling the first electrode to the pin;  
 mounting the electrode assembly in the interior volume with the pin  
 extending out through the first wall opening;  
 mounting the first end cap to seal the first wall opening;  
 5 providing a second end cap of electrically conductive material; and  
 electrically coupling the second electrode to the second end cap;  
 depositing electrolyte into the case through the second wall opening; and  
 mounting the end cap in the second wall opening to seal the second wall  
 opening.

10 <sup>58</sup>  
~~57~~. The electric storage battery of claim 56 wherein the step of electrically  
 coupling the second electrode to the second end cap precedes the step of  
 depositing electrolyte into the case through the second wall opening.

15 <sup>59</sup>  
~~58~~. A method of constructing an electric storage battery including:  
 providing a case comprising a peripheral wall of electrically conductive  
 material defining an interior volume and having first and second wall openings  
 communicating with the interior volume;  
 providing an electrically conductive terminal pin extending through the first  
 20 end cap and electrically insulated from the case;  
 providing an electrode assembly comprising first and second opposite  
 polarity electrodes  
 electrically coupling the first electrode to the pin;  
 mounting the electrode assembly in the interior volume with the pin  
 25 extending out through the first wall opening;  
 mounting the first end cap to seal the first wall opening;  
 providing a second end cap of electrically conductive material; and  
 electrically coupling the second electrode to the second end cap;  
 depositing electrolyte into the case through the second wall opening; and  
 30 mounting the end cap in the second wall opening to seal the second wall  
 opening.

<sup>60</sup>  
~~59~~. The method of claim 58 wherein the step of electrically coupling the  
 second electrode to the second end cap precedes the step of depositing  
 35 electrolyte into the case through the second wall opening.

60. A hermetically sealable electric storage battery comprising:  
 a case having an open end;  
 a first electrically conductive terminal electrically insulated from said case;  
 5 an electrode assembly disposed within said case and comprising first and second opposite polarity electrodes separated by separators wherein said first electrode is electrically coupled to said first terminal;  
 a flexible conductive tab electrically coupled to said second electrode proximate a first location at said case open end;  
 10 said tab electrically connected to said end cap at a second location whereby said end cap has a first bias position tending to keep said case open end open and a second bias position tending to close said case open end.
61. The battery of claim 60 wherein said first bias position orients said end  
 15 cap approximately perpendicular to said open end.
62. The battery of claim 60 wherein said second end cap is welded to said tab flat against an inner face of said second end cap.
63. The battery of claim 60 wherein:  
 20 said end cap is circular and has a radius  $R$ ;  
 the distance from said second location to said case open end is a length  $L$ ; and  
 $L \leq 2R$ .
64. The battery of claim 63 wherein said second location is above the center  
 25 of said end cap in said first bias position.
65. The battery of claim 63 wherein said end cap overlaps the case by  
 30 approximately  $R/2$  in said second bias position.